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THE IMPACT OF NATURE OF SCIENCE ACTIVITIES ON SCIENCE TEACHER CANDIDATES' VIEWS ON THE NOS AND THEIR SELF-EFFICACY BELIEFS ABOUT TEACHING THE NOS

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Abstract: This study aims to examine the effects of explicit-reflective nature of science (NOS) activities on science teacher candidates' views on the nature of science and self-efficacy beliefs about teaching the nature of science, using a single-group pre-test-post-test experimental method. The research sample included 120 science teacher candidates studying at public universities in Turkey's Marmara and Central Anatolia Regions during the second semester of the academic term 2017-2018. Data were collected using the "Views Questionnaire on the Nature of Science-VNOS-C" and "Self-Efficacy Scale for Nature of Science Knowledge and Instruction". For data analysis we used statistically related samples t-Test, descriptive statistics using frequency (f)-percentage (%) and content analysis. Participants' beliefs for teaching the nature of science positively changed after the applications ($p<.01$). Also, views in all dimensions of the nature of science have increased at an "acceptable" level as well. According to the findings, nature of science activities enhanced students' views about the nature of science and their self-efficacy beliefs about tutoring the nature of science.

Key words: nature of science, self-efficacy, view, nature of science activities

1. Introduction

Science contains imprecise information that is open to change, information gained from natural world observations, subjective theoretical perspectives, creative and imaginative human inferences, and social and cultural values (Lederman, Abd-El-Khalick, Bell & Schwartz, 2002). According to this definition, the Nature of Science (NOS), like the science's own description, is a notion that cannot be agreed upon since science is always changing and developing (Demirbaş & Balcı, 2013; Doğan, Çakıroğlu, Bilican & Çavuş, 2012). For this reason, it would be appropriate to explain the NOS from a broad perspective which includes science and scientific knowledge. Demirbaş and Balcı (2013) describe the link between scientific knowledge ideas and NOS by including scientific knowledge into NOS. While scientific knowledge includes scientific theories and laws, NOS includes scientific publications and the work of scientists along with these studies. It also deals with how scientific knowledge is produced and under what conditions it is valid. NOS covers a wide range of topics, including the science philosophy, science history, science psychology and science sociology. McComas, Clough and Almazroa (1998) pointed out that NOS consists of components related to the philosophy, history, psychology, and sociology of science, and in this respect, it is a multidimensional concept with a broader and more specific definition. Based on this explanation, NOS involves a multiple approach with different dimensions like changes in scientific studies from past to present, society and culture directing and being affected by scientific activities, scientists using their imagination and creativity during their studies, and philosophical trends followed in the realization of scientific activities.

Assimilating NOS in a broad framework is of great importance in terms of being scientifically literate. Namely, this concept includes knowing the characteristics of scientists with scientific knowledge, having an idea about scientific events in every field, being conscious of the dynamic interaction that exists between society and science (Driver, Leach, Millar & Scott, 1996). Previously connected with scientific process skills, the nature of science is now more related with values, beliefs, and perspectives

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(Lederman & Zeidler, 1987). While highlighting the changing structure of scientific knowledge, it requires more detailed research on the concepts (e.g., law, theory, observation, inference, scientific method, social-cultural values) examined within the scope of scientific knowledge. Although there are numerous disagreements over the definition of NOS, a consensus has been achieved on its main sub-dimensions based on the research of science tutors, sociologists, historians, and philosophers. (Abd-El-Khalick, Bell & Lederman, 1998; Lederman et al., 2002; McComas & Olson, 1998). These dimensions are:

- All kinds of scientific knowledge are prone to alteration.
- Experimentation and observation are the foundations of scientific knowledge.
- Creativity and imagination are critical components in the disposition of scientific knowledge.
- Laws and theories are two sorts of scientific knowledge that serve distinct purposes.
- There is no single technique for conducting scientific knowledge.
- Observation and inference are different things.
- The social and cultural context has an impact on scientific knowledge.

As a result of the definitions of these dimensions and the theoretical structure of the relations between them, it is possible to gather extensive information regarding the nature of scientific knowledge. For this reason, it is extremely important that these dimensions are correctly understood by the students in the learning environment. In this context, undoubtedly, great responsibility falls on teachers.

In the science curriculum from our country, the acquisitions connected to NOS are arranged in the scope of Science-Technology-Society-Environment learning area in a way that will enable students to understand NOS and effectively use what they have learned in science into other fields (MEB, 2006). It should be examined whether the NOS learning outcomes, the boundaries of which are drawn in the learning domain, are due to the teaching done properly by the teachers. In a way this is related to the tutor's understanding of NOS and whether this is reflected in the planning of classroom practice is an important issue (Lederman, 1999). According to Kim (2006), the premise in this research is that instructors' proper grasp of NOS would be translated into classroom practices and consequently transmitted to their pupils. Establishing the relationship between teachers' discrepancies of NOS understanding and their classroom practices is of major importance.

However, science teachers need support to translate their understanding of NOS into science teaching (Kim, 2006). The emphasis is on the importance of developing teachers' pedagogical knowledge and skills along with their knowledge of the NOS (Hanuscin, Lee & Akerson, 2010). Despite this, according to the research, instructors who are practitioners of scientific knowledge lack enough awareness of the NOS concept (Abd-El-Khalick & Lederman, 2000; Aslan, 2009; Doğan Bora, Arslan & Çakıroğlu, 2006; Lederman, 2007; Taşar, 2003; Zeidler, Walker, Ackett & Simmons, 2002). It can also be based on the argument that teachers are not prepared to teach NOS in their classes. Because NOS includes the fact that the content knowledge (such as atom, mass, weight, reproduction) and related information in the content of science may change over time in the light of new findings, scientific activities may differ according to the expectations of society and culture, and the understanding of doing science may be affected by the unique characteristics of scientists. Thus, such a complex concept should first be understood by teachers to be taught to students. For this reason, teachers should first have a sufficient understanding of this subject and then, while teaching a scientific concept in classrooms, it is also essential that students acquire the characteristics of NOS. If science teachers want their students to develop a better understanding of this subject, they must first understand themselves the NOS concept and its relation to teaching science (Vaughan, 2000). According to Akerson, Hanson and Cullen (2007), teachers will not be successful in any related topic without adequate perspectives on the NOS.

Investigating teachers' self-efficacy beliefs about teaching nature of science as well as their knowledge about nature of science is regarded to be beneficial. The concept of self-efficacy first emerged with Bandura's Social Learning Theory. A person's perceived ability to cope with an averted occurrence is also included in Bandura's concept of self-efficacy (Eastman & Marzillier, 1984). Personal expectations, the strength of individuals' beliefs about their own effectiveness, affect whether they can cope with certain situations. Perceived self-efficacy in the initial stage guides one's behavior selection (Bandura, 1977). For this reason, the teacher's self-belief in overcoming all kinds of situations that he/she may encounter in classroom practices will affect instructional activities. While self-efficacy has a guiding effect on the choice of activities and environments, the desire to be successful in that job also affects the coping effort. The more one's self-efficacy, the more active one's endeavors (Bandura, 1977). In other words, a person's past achievements and beliefs about certain tasks influence one's beliefs in coping with certain situations. According to Kubilay Tatar and Özenoğlu (2018), the scarce knowledge of teachers regarding the nature of science and their low self-efficacy in teaching can explain the low level of scientifically literate individuals. Consequently, it is essential to guarantee that teacher candidates get all the parts associated with NOS through classroom activities, as well as to improve their beliefs and desires in dealing with the problems they may encounter when teaching this idea.

Research on teaching and comprehending the nature of science indicates that it is worth exploring the way in which instructors make students understand this topic (Forawi, 2014). There are historical, indirect, and explicit-reflective approaches in the literature on this subject. Among these, it is stated that the open-minded approach provides sufficient understanding of the NOS on teacher/candidate teachers (Akerson, Abd-El-Khalick & Lederman, 2000; Akerson et al., 2007; Ayvacı, 2007; Köseoğlu, Tümay & Üstün, 2010) and primary school students (Forawi, 2014; Khishfe & Abd-El-Khalick, 2002; Khishfe, 2008; Küçük, 2006; Melville, 2011).

Implicit learning including activities based on research inquiry would assume to develop students' true NOS concepts, but studies show that explicit-reflective teaching is needed to develop informed NOS concepts (Akerson et al., 2007; Bell, Blair, Crawford & Lederman, 2003; Lederman, 2007; Melville, 2011). The explicit-reflective approach is one in which students are given repeated chances to reflect on the activities in which they engage from various viewpoints and link these new concepts to the growth of scientific knowledge and the activity of scientists (Melville, 2011). In other words, this technique is required to connect scientists' real-world operations with NOS concepts. Following each activity, components of the NOS should be freely addressed to obtain a better knowledge of the genuine essence of scientists' job (Akerson et al., 2007). The approach's efficacy is beneficial in that the activities utilized provide valuable experiences about how science works, the traits of scientists, and scientific knowledge (Köseoğlu et al., 2010).

This research has its basis on explicit-reflective approach activities related to the nature of science in pre-service teachers. The improvement of students' understanding of the subdimensions of NOS and of the impact that scientists had over time on scientific knowledge attainment were addressed through activities carried out in this research, considering current conditions like the characteristics of the periods in which they lived, scientific methods and the methods they used to express their thoughts. In this context, the study is original and will contribute to the knowledge in this field.

1.1. Aim

This research investigates the impact of explicit-reflective nature of science activities on science pre-service teachers' perceptions of NOS along with the self-efficacy beliefs about teaching NOS. Thus, participants were asked to answer to the following research questions.

1.2. Research Questions

1. What influence do NOS activities relying on an explicit-reflective approach have on the self-efficacy perceptions of science teacher candidates regarding teaching Nature of Science?
2. What effect do NOS activities relying on an explicit-reflective approach have on science teacher candidates' perceptions of NOS?
3. Is there a statistically meaningful variation among the pre-post test points for each item of science teacher candidates' opinions on NOS?

2. Method

2.1. Research Method

This study employed the mixed research approach. This method has been defined as the use of qualitative and quantitative approaches together in a research while seeking answers to research problems (Creswell, 2012). The qualitative dimension of the study consisted of determining the opinions of prospective teachers about NOS through a survey. The quantitative dimension consisted of the rubric that is used to determine the understandings of the NOS with quantitative scores and self-efficacy beliefs scale towards teaching NOS. In the quantitative part of the study, a single-group pre-test-post-test experimental design was used. In this design, an independent variable is applied to a randomly formed group, and a measurement is made before and after the experiment (Fraenkel & Wallen, 2011; Özmen, 2015). The distinction between the pre and post test means shows the effect of the independent variable on the dependent variable. "The independent variable in this study is 'NOS activities based on an explicit-reflective approach,' while the dependent variables are 'science teacher candidates' views on the NOS' and 'their self-efficacy beliefs."

2.2. Participants

The study's participants included 120 science teacher candidates studying at state universities in Turkey's Marmara and Central Anatolia regions. 102 (85%) of the teacher candidates are female and 18 (15%) are male.

2.3. Designing Activities Appropriate with a Contemplative Approach

In this study, in which the understanding of the sub-dimensions of the NOS was developed through activities suitable for the explicit-reflective approach of the pre-service teachers, these dimensions, as shown in Table 1, were taught through different activities every week. In this context, firstly, weekly lesson plans were prepared. In the lesson plans, the weekly course content, the nature of science achievements, activities based on explicit-reflective approach were prepared within the course hours. In the study, videos, written documents suitable for the course content, and textbooks were used as teaching materials. As data sources, feedback from the participants about the activities performed during the lesson, discussion, question-answer, a summary report on the summary of the lesson in the evaluation dimension, as well as evaluation questionnaires with open-ended questions were made use of. In this way, the in-depth evaluation of the activities within the scope of the NOS sub-dimensions and their effects on teaching were discussed.

Worksheet example:

- What do you think about the place and importance of scientific developments in the Islamic world in our lives?
- Are the current conditions of scientists (inventions, previous experiences, experiences, education, social structure, etc.) effective in the development of scientific knowledge? Explain why?
- What sub-dimensions are there in the mystery cubes event (Doğan et al., 2012) NOS? Why is that?

2.4. Application of Nature of Science Activities

This study was carried out within the 3rd year "Nature of Science and History of Science" course in Science Education. The study lasted for 12 weeks and activities in accordance with the open-minded approach in teaching the nature of science were carried out every week. With the activities implemented, it was aimed to develop the views of the pre-service teachers about a dimension of the NOS positively changed every week. The activities implemented for 12 weeks are presented in Table 1.

Table 1. *The applied activities and the NOS aimed to be increased.*

NOS Dimension	Activity/Event Number*											
	1	2	3	4	5	6	7	8	9	10	11	12
Distinction among inference and observation	√	√		√	√		√			√		
Observation and inference are the foundations of scientific knowledge					√	√			√		√	√
Changeability of scientific knowledge	√	√	√	√	√	√	√					√
Testing the scientific knowledge			√	√					√			

Impartiality of scientific knowledge								√				
The imagination and inventive essence of scientific knowledge	√	√	√	√	√		√	√	√	√	√	√
Subjectivity of scientists	√	√	√			√	√	√			√	√
Science cannot be done alone	√											
Acceptances and limits of science									√			
Scientific knowledge relies on theory		√		√		√					√	
Contribution of socio-cultural environment in the development of science		√	√					√				
Scientific models are not the same as the reality of observed events		√		√	√							

*Activity/Event numbers:

No.1: Tangram, No.2: Mysterious cubes, No.3: Catapult, No.4: What's in the tube?, No.5: Black box, No.6: Mysterious treasure, No.7: Footprints, No.8: Science-technology relationship: Pipette tower, No.9: Frontiers of science, No.10: Sequence of events, No.11: Young-Old, No.12: Fossils I-Fossils II

2.5. Tools of Gathering Data

In this study, the "Views Questionnaire on the Nature of Science-VNOS-C" and "Self-Efficacy Scale for Nature of Science Knowledge and Instruction" were utilized as tools of gathering the data.

2.5.1. Views Questionnaire on the Nature of Science (VQNS) VNOS-C

One of the dependent variables of this study is the views of pre-service teachers about the NOS. To find out how the nature of science activities affect this variable, the Survey of Views on the Nature of Science, which consists of 10 open-ended questions developed by Abd-El-Khalick, Lederman, Bell, and Schwartz (2001) and adapted into Turkish by Özcan (2013), was used. This questionnaire includes 7 sub-dimensions of the NOS. The relationship between the NOS sub-dimensions in the questionnaire and the questionnaire items is presented in Table 2 (Özcan, 2013):

Table 1. *The relationship between the sub-dimensions of the NOS and the VQNS items*

NOS Sub-dimensions	VQNS Item Provisions
1. Scientific knowledge is open to change. (Changeability)	1, 6, 7, 9, 10
2. Scientific knowledge has an experimental nature. (Experimentation)	1, 2, 3, 6, 7, 9
3. Scientific knowledge is based on inferences as well as observations. (Observation and Inference)	6, 7, 9
4. Scientific theories and scientific laws are different kinds of knowledge. (Theory and Law)	5
5. Scientific knowledge is loaded with theory. (Theoretical Burden)	6, 9
6. Scientific knowledge includes imagination and creativity. (Imagination and Creativity)	1, 4, 6, 7, 8, 9
7. Scientific knowledge is affected by social and cultural values. (Social and Cultural Impact)	1, 9, 10

2.5.2. Self-Efficacy Scale for Nature of Science Knowledge and Instruction (SESNOSKI)

The Self-Efficacy Beliefs Scale for Teaching the Nature of Science (SESNOSKI), developed by Kubilay Tatar and Özenoğlu (2018), was used to see how the nature of scientific activities affected prospective teachers' self-efficacy beliefs in teaching the NOS. The test is in the form of a five-point Likert scale with 30 items and two dimensions. The first dimension is the Self-Efficacy Belief in Teaching the Nature of Science, and the second dimension is the Self-Efficacy Belief in the NOS.

2.6. Data Examination

The data acquired in this research was initially evaluated to see if it had a normal distribution. The Kolmogorov-Smirnov test was chosen to use since the sample size of the study was larger than 30. Regarding the self-efficacy beliefs variable, it was concluded that the distribution of the data obtained from the SESNOSKI was normal (pre-test p=.08, post-test p=.20, p>.05). The data obtained from the VQNS, which is used to determine the views of pre-service teachers about the NOS, also has a normal distribution (pre-test p=.20, post-test p=.19, p>.05). For this reason, parametric tests were used to compare the data obtained before and after the implementation of the nature of science activities. The data were analyzed with the SPSS-15 package software.

Numerous rubric scoring systems have been developed for the evaluation of views on NOS in the literature (Akerson & Donnelly, 2010; Lederman et al., 2002; Abd-El-Khalick, Waters & Le, 2008; Griffard, Mosleh & Kubba, 2013). In this study, the rubric developed by Özcan (2013) for VQNS was utilized. According to this, each item of VQNS is referred to as “measured” and the evaluation of the given responses is expressed as “criteria”. Özcan (2013) categorized the criteria in the rubric as “Unacceptable”, “Partially acceptable” and “Acceptable”. In the evaluation of performance-based rubric, there is an evaluation in the light of certain levels, not precise judgments such as right or wrong (Goodrich, 1997, cited in Özcan, 2013). In this context, the expressions of teacher candidates corresponding to the “unacceptable” criterion can be considered as poor performance by teacher candidates, while the expression of teacher candidates corresponding to the “acceptable” criterion can be considered as the best performance by teacher candidates. Other teacher candidate performances that do not fall within these two criteria can be regarded as corresponding to the “partially acceptable” criterion. The scoring of the criteria in the rubric scoring system was determined as follows: 'unacceptable' (0 points), 'partially acceptable' (1 point), and 'acceptable' (3.5 points) (Özcan, 2013). The purpose of this is to express the understanding of the NOS with quantitative scores (Özcan, 2013). Considering this information, content analysis was performed according to the rubric in the VQNS analysis. In this context, Unacceptable (U), Partially Acceptable (PA) and Acceptable (A) evaluation criteria were used in the analysis of the questionnaire. Accordingly, the answers given by the candidates were scored in a way that corresponds to 0, 1 and 3.5 points, respectively, within the scope of these criteria. In this context, t-test was used for related samples to determine if there is a meaningful statistical difference in the pre and post test scores for each item on participants' views on the NOS. In the literature, it is stated that the t-test is used to test whether there is a significant difference between the means of two related samples (Frankel & Wallen, 2011). Accordingly, in this study, the t-test was used to measure whether the development of pre-service teachers' views on the nature of science through explicit-reflective nature of science activities significantly differed over time.

3. Findings

3.1. Findings Related to Pre-Service Teachers' Self-Efficacy Beliefs towards Teaching the NOS

The findings related to the analysis of the SESNOSKI's data used to measure the pre-service teachers' self-efficacy beliefs are presented in Table 3.

Table 2. *Comparison of pre-test and post-test scores of pre-service teachers' self-efficacy beliefs for teaching the nature of science scale with dependent groups t-Test*

Dimensions of the Scale	Measurement (SESNOSKI)	N	X	SD	df	t	p
First dimension	Pre-test	120	72.39	9.10	113	5.06	.000*
	Post-test	120	77.99	12.05			
Second dimension	Pre-test	120	36.90	5.21	110	2.78	.006*
	Post-test	120	38.74	5.75			
Overall scale	Pre-test	120	109.31	12.73	106	4.38	.000*
	Post-test	120	116.56	16.82			

*p<.01

According to Table 3, a significant difference was observed between the scores obtained from pre and post test of the participants in terms of their self-efficacy beliefs in teaching nature of science (p<.01). Similarly, the study revealed a substantial change among the participants' scores of pre and post tests on the second dimension of the test, “Self-Efficacy Belief in the Nature of Science” (p<.01). When the analyzes of the overall scale are evaluated, we observe that while the mean score of the pre-service teachers was X=109.31 before the applications, this average score increased to X=116.56 after the applications. In other words, it was discovered that after participating in NOS activities, participants' self-efficacy beliefs in teaching NOS increased significantly (p<.01). This finding shows that activities focused on nature of science have a significant effect on increasing pre-service teachers' self-efficacy beliefs about teaching NOS.

3.2. Findings Related to Pre-Service Teachers' Views on the Nature of Science

The results of the examination of each dimension of the VQNS data used to assess teacher candidates' perspectives on the NOS are shown in separate tables below.

Table 3. *Findings on participants' answers to the first sub-dimension of VQNS*

VQNS Item Number	Pre-test			Post-test			For Related Samples t-Test						
	U	PA	A	U	PA	A							
	f %	f %	f %	f %	f %	f %		N	X	SD	df	t	p
1a	65	42	13	55	33	32	Pre-test	120	.72	1.07	119	2.89	**.005**
	52.4	33.9	10.5	44.4	26.6	25.8	Post-test	120	1.20	1.44			
1b	55	20	45	62	25	33	Pre-test	120	1.47	1.61	119	1.65	.101
	44.4	16.1	36.3	50	20.2	26.6	Post-test	120	1.17	1.49			
6a	29	76	13	38	32	40	Pre-test	120	1.03	.96	119	3.70	**.000**
	23.4	61.3	10.5	30.6	25.8	32.3	Post-test	120	1.56	1.45			
6b	75	27	12	49	54	14	Pre-test	120	.60	1.05	119	2.06	.041
	60.5	21.8	9.7	39.5	43.5	11.3	Post-test	120	.88	1.06			
7a	83	35	1	68	46	6	Pre-test	120	.32	.54	119	2.77	**.006**
	66.9	28.2	.8	54.8	37.1	4.8	Post-test	120	.55	.83			
7b	78	37	2	41	62	14	Pre-test	120	.37	.61	119	5.63	**.000**
	62.9	29.8	1.6	33.1	50	11.3	Post-test	120	.94	1.03			
9	30	53	35	7	25	88	Pre-test	120	1.48	1.36	119	8.40	**.000**
	24.2	42.7	28.2	5.6	20.2	7.1	Post-test	120	2.77	1.22			
10	24	45	51	3	5	112	Pre-test	120	1.86	1.45	119	10.01	**.000**
	19.4	36.3	41.1	2.4	4	90.3	Post-test	120	3.30	.73			

As shown in Table 4, a positive change in the questions about the changeability dimension of scientific knowledge is observed. Except for question 1b, there is an increase in the rate of acceptable opinion from the pretest to the posttest in all the questions representing this dimension. Related samples t-test analysis results confirm that this finding is statistically significant. Except for questions 1b and 6b, a meaningful statistical difference was retained between the scores of pre and post test in all other questions (p<.05). This situation shows that the applications made have a positive effect on the opinions of pre-service teachers about the changeability dimension of science.

Table 5. *Findings on participants' answers to the second sub-dimension of VQNS*

VQNS Item Number	Pre-test			Post-test			For Related Samples t-Test						
	U	PA	A	U	PA	A							
	f %	f %	f %	f %	f %	f %		N	X	SD	df	t	p
1a	65	42	13	55	33	32	Pre-test	120	.72	1.07	119	2.89	**.005**
	52.4	33.9	10.5	44.4	26.6	25.8	Post-test	120	1.20	1.44			
1b	55	20	45	62	25	33	Pre-test	120	1.47	1.61	119	1.65	.101
	44.4	16.1	36.3	50	20.2	26.6	Post-test	120	1.17	1.49			
2	90	28	2	94	16	10	Pre-test	120	.29	.59	119	1.36	.173

	72.6	22.6	1.6	75.8	12.9	8.1	Post-test	120	.42	.99			
3	111	7	2	69	30	21	Pre-test	120	.11	.50	119	6.15	**.000**
	89.5	5.6	1.6	55.6	24.2	16.9	Post-test	120	.86	1.28			
6a	29	76	13	38	32	40	Pre-test	120	1.03	.96	119	3.70	**.000**
	23.4	61.3	10.5	30.6	25.8	32.3	Post-test	120	1.56	1.45			
6b	75	27	12	49	54	14	Pre-test	120	.60	1.05	119	2.06	.041
	60.5	21.8	9.7	39.5	43.5	11.3	Post-test	120	.88	1.06			
7a	83	35	1	68	46	6	Pre-test	120	.32	.54	119	2.77	**.006**
	66.9	28.2	.8	54.8	37.1	4.8	Post-test	120	.55	.83			
7b	78	37	2	41	62	14	Pre-test	120	.37	.61	119	5.63	**.000**
	62.9	29.8	1.6	33.1	50	11.3	Post-test	120	.94	1.03			
9	30	53	35	7	25	88	Pre-test	120	1.48	1.36	119	8.40	**.000**
	24.2	42.7	28.2	5.6	20.2	7.1	Post-test	120	2.77	1.22			

In Table 5 we see that the rate of acceptable views of pre-service teachers increased for all questions, except for questions 1b, 2 and 6b, which include the experimental dimension of the NOS, and the rate of unacceptable views generally decreased. The results of unrelated samples t-test analysis also support this situation (p<.05). These results indicate that prospective teachers' opinions on the experimental part of science have shifted significantly.

Table 6. *Findings on participants' answers to the third sub-dimension of VQNS*

VQNS Item Number	**Pre-test**			**Post-test**			**For Related Samples t-Test**						
	U	**PA**	**A**	**U**	**PA**	**A**							
	f / **%**	**f** / **%**	**f** / **%**	**f** / **%**	**f** / **%**	**f** / **%**		**N**	**X**	**SD**	**df**	**t**	**p**
6a	29	76	13	38	32	40	Pre-test	120	1.03	.96	119	3.70	**.000**
	23.4	61.3	10.5	30.6	25.8	32.3	Post-test	120	1.56	1.45			
6b	75	27	12	49	54	14	Pre-test	120	.60	1.05	119	2.06	.041
	60.5	21.8	9.7	39.5	43.5	11.3	Post-test	120	.88	1.06			
7a	83	35	1	68	46	6	Pre-test	120	.32	.54	119	2.77	**.006**
	66.9	28.2	.8	54.8	37.1	4.8	Post-test	120	.55	.83			
7b	78	37	2	41	62	14	Pre-test	120	.37	.61	119	5.63	**.000**
	62.9	29.8	1.6	33.1	50	11.3	Post-test	120	.94	1.03			
9	30	53	35	7	25	88	Pre-test	120	1.48	1.36	119	8.40	**.000**
	24.2	42.7	28.2	5.6	20.2	7.1	Post-test	120	2.77	1.22			

Table 6 shows that the respondents' acceptable views improved in all questions under the dimension of observation and inference between pre and post test. Except for question 6b (p<.05), there is a statistically significant difference between the pre-test and post-test in all other questions when considering the statistical significance of this finding. In short, all these findings were interpreted as the positive development of pre-service teachers' views on this dimension.

Table 7. *Findings on participants' answers to the fourth sub-dimension of VQNS*

VQNS Item Number	**Pre-test**			**Post-test**			**For Related Samples t-Test**						
	U	**PA**	**A**	**U**	**PA**	**A**							
	f / **%**	**f** / **%**	**f** / **%**	**f** / **%**	**f** / **%**	**f** / **%**		**N**	**X**	**SD**	**df**	**t**	**p**
5	73	35	11	19	73	27	Pre-test	120	.61	1.02	119	7.55	**.000**
	58.9	28.2	8.9	15.3	58.9	21.8	Post-test	120	1.40	1.18			

When we analyze the results of question 5, which represents the dimension of scientific theories and laws (Table 7), we can see that the unacceptable opinion of the teacher candidates was preferred by

58.9% in the pre-test, and this opinion decreased to 15.3% in the post-test. While 28.2 percent of respondents favoured a somewhat acceptable view in the pre-test, this number rose to 58.9% in the post-test. 8.9% of individuals had acceptable thoughts in the pre-test, where this number increased to 21.8 percent in the post-test. The t-test result was likewise significant for the related samples, which were used to examine if participants' opinions on theory and law had changed from the pre- to post-test period (p<.05). This shows that there is a significant relationship between the opinions in the pre- and post-tests.

Table 8. *Findings on participants' answers to the fifth sub-dimension of VQNS*

VQNS Item Number	Pre-test			Post-test			For Related Samples t-Test						
	U	PA	A	U	PA	A							
	f / %	f / %	f / %	f / %	f / %	f / %		N	X	SD	df	t	p
6a	29	76	13	38	32	40	Pre-test	120	1.03	.96	119	3.70	**.000**
	23.4	61.3	10.5	30.6	25.8	32.3	Post-test	120	1.56	1.45			
6b	75	27	12	49	54	14	Pre-test	120	.60	1.05	119	2.06	.041
	60.5	21.8	9.7	39.5	43.5	11.3	Post-test	120	.88	1.06			
9	30	53	35	7	25	88	Pre-test	120	1.48	1.36	119	8.40	**.000**
	24.2	42.7	28.2	5.6	20.2	7.1	Post-test	120	2.77	1.22			

When Table 8 is examined, one can conclude that the rate of acceptable opinions of participants regarding the dimension of scientific knowledge theory load in the pre-test increased in the post-test. Except for the 6b numbered question representing this dimension, the related samples t-test results applied to the 6a, and 9 questions were also statistically significant (p<.05). This situation shows that the views of pre-service teachers are loaded with scientific knowledge theory after the applications.

Table 9. *Findings on participants' answers to the sixth sub-dimension of VQNS*

VQNS Item Number	Pre-test			Post-test			For Related Samples t-Test						
	U	PA	A	U	PA	A							
	f / %	f / %	f / %	f / %	f / %	f / %		N	X	SD	df	t	p
1a	65	42	13	55	33	32	Pre-test	120	.72	1.07	119	2.89	**.005**
	52.4	33.9	10.5	44.4	26.6	25.8	Post-test	120	1.20	1.44			
1b	55	20	45	62	25	33	Pre-test	120	1.47	1.61	119	1.65	.101
	44.4	16.1	36.3	50	20.2	26.6	Post-test	120	1.17	1.49			
4a	49	55	16	39	53	28	Pre-test	120	.92	1.11	119	2.68	**.008**
	39.5	44.4	12.9	31.5	42.7	22.6	Post-test	120	1.25	1.31			
4b	23	51	38	49	40	28	Pre-test	120	1.64	1.34	119	2.77	**.006**
	18.5	41.1	30.6	39.5	32.3	22.6	Post-test	120	1.17	1.36			
6a	29	76	13	38	32	40	Pre-test	120	1.03	.96	119	3.70	**.000**
	23.4	61.3	10.5	30.6	25.8	32.3	Post-test	120	1.56	1.45			
6b	75	27	12	49	54	14	Pre-test	120	.60	1.05	119	2.06	.041
	60.5	21.8	9.7	39.5	43.5	11.3	Post-test	120	.88	1.06			
7a	83	35	1	68	46	6	Pre-test	120	.32	.54	119	2.77	**.006**
	66.9	28.2	.8	54.8	37.1	4.8	Post-test	120	.55	.83			
7b	78	37	2	41	62	14	Pre-test	120	.37	.61	119	5.63	**.000**
	62.9	29.8	1.6	33.1	50	11.3	Post-test	120	.94	1.03			
8a	9	94	10	23	46	35	Pre-test	120	1.14	.76	119	3.83	**.000**
	7.3	75.8	8.1	18.5	37.1	28.2	Post-test	120	1.62	1.30			
8b	25	55	29	6	37	67	Pre-test	120	1.43	1.24	119	6.86	**.000**
	20.2	44.4	23.4	4.8	29.8	54	Post-test	120	2.46	1.25			

9	30	53	35	7	25	88	Pre-test	120	1.48	1.36	119	8.40	**.000**
	24.2	42.7	28.2	5.6	20.2	7.1	Post-test	120	2.77	1.22			

When the items that make up the imagination and creativity dimension of scientific knowledge in Table 9 are examined, one observes that the unacceptable views of the pre-test in questions 1b, 4b, 6a and 8a increased in the post-test. Furthermore, the unacceptable views of items 1a, 4a, 6b, 7a, 7b, 8b and 9 in the pre-test decreased in the post-test. In some questions (1b, 6b, 7a, and 7b), the rate of partially acceptable opinion increased from the pretest to the posttest, while in all other questions, except for questions 1b and 4b, the rate of acceptable opinion increased in the posttest. When the related samples t-test analysis results are also examined, it confirms this finding (p<.05).

Table 10. *Findings on participants' answers to the seventh sub-dimension of VQNS*

VQNS Item Number	**Pre-test**			**Post-test**			**For Related Samples t-Test**						
	U	**PA**	**A**	**U**	**PA**	**A**							
	f / **%**	**f** / **%**	**f** / **%**	**f** / **%**	**f** / **%**	**f** / **%**		**N**	**X**	**SD**	**df**	**t**	**p**
1a	65	42	13	55	33	32	Pre-test	120	.72	1.07	119	2.89	**.005**
	52.4	33.9	10.5	44.4	26.6	25.8	Post-test	120	1.20	1.44			
1b	55	20	45	62	25	33	Pre-test	120	1.47	1.61	119	1.65	.101
	44.4	16.1	36.3	50	20.2	26.6	Post-test	120	1.17	1.49			
9	30	53	35	7	25	88	Pre-test	120	1.48	1.36	119	8.40	**.000**
	24.2	42.7	28.2	5.6	20.2	7.1	Post-test	120	2.77	1.22			
10	24	45	51	3	5	112	Pre-test	120	1.86	1.45	119	10.01	**.000**
	19.4	36.3	41.1	2.4	4	90.3	Post-test	120	3.30	.73			

According to Table 10, except for question 1b, which constitutes the dimension of the social and cultural impact of scientific knowledge, the acceptable opinion rates of teacher candidates have increased positively. In general, when the questions representing this dimension were examined, the rate of unacceptable views decreased from the pretest to the posttest, and the rate of acceptable views increased. The related samples t-test, which was used to measure changes in participants' perceptions of science's social and cultural effect from pre to post test, yielded statistically significant results (p<.05).

4. Discussion

This study is focused on examining the effect of the explicit-reflective approach-based nature of science activities on pre-service science teachers' views on the NOS and their self-efficacy beliefs toward teaching the NOS. Results indicate that pre-service science teachers' self-efficacy beliefs toward teaching the NOS increased significantly after the interventions, and it was seen that the views on all dimensions of the NOS increased at an "acceptable level", which means positively changed. These results and their reasons are discussed and interpreted in detail below.

Regarding the Self-Efficacy Scale for Nature of Science Knowledge and Instruction, a statistically significant difference was found in favor of the post-test in terms of the scores for both the overall scale and its dimensions (Table 3). This finding indicates that NOS activities based on the explicit-reflective approach have a positive impact on science teachers' self-efficacy in teaching NOS. Additionally, this can be interpreted as pre-service teachers viewing themselves as competent to teach their students about the NOS in the future, as Bandura (1997) proposed that self-efficacy is an individuals' belief in their ability to perform a task. In this context, Mıhladız (2010) stated that pre-service teachers are less effective in teaching the NOS to their students when their self-efficacy beliefs are weak. Kubilay Tatar and Özenoğlu (2018) also emphasized that teachers with high self-efficacy about teaching NOS are essential for fostering students' sufficient understanding of NOS. The results of VQNS demonstrate that the pre-service teachers' views regarding the changeability dimension of scientific knowledge changed significantly from the "unacceptable" view to the "acceptable view" level after the interventions. The dependent sample t-test analysis between the pretest and posttest scores are significantly different

(Table 4). This can be interpreted as the nature of science activities causing pre-service teachers' understandings that scientific information can be reinterpreted and changed in the light of new information. This result is related to previous studies' results conducted by other researchers (Aslan, 2009; Ayvacı & Özbek, 2019; Çelik, 2016; İmer Çetin, 2013; Lederman, 1999; Mıhladız, 2010).

In the experimental dimension of science, participants' unfavorable opinions decreased, while their acceptable views increased after the interventions. Additionally, the p-values obtained from the dependent sample t-test analysis indicated a significant difference between the pretest and posttest scores (Table 5). This is consistent with the findings of Çelik (2016), who also reported that participants held acceptable views regarding the experimental dimension of scientific knowledge.

Pre-service teachers' views on the observation and inference dimension of the NOS improved significantly after the interventions, as supported by the results of the dependent sample t-test for each question (Table 6).

Pre-service teachers' unacceptable views about scientific theories and laws transformed into acceptable views following the interventions. Moreover, a meaningful difference between the scores obtained from pre and post tests of pre-service teachers was observed (Table 7). Previous studies demonstrated that there are many misconceptions that theory and law are different types of information (Doğan Bora, 2005; Küçük, 2008). Most people believe that there is a hierarchical order between theories and laws, and that theories will turn into laws when supported by sufficient data (Aslan, 2009; Parker, Krockover, Lasher-Trapp & Eichinger, 2008; Saraç, 2012).

The findings related to the fifth sub-dimension of the NOS indicate that the unacceptable views of participants shifted to the acceptable level after the interventions. Consistent with previous studies (Köseoğlu et al., 2010), pre-service teachers' acceptable views increased after the interventions (Table 8). Furthermore, pre-service teachers' views on the imagination and creativity dimension of scientific knowledge showed positive development with an overall increase in acceptable views in the post-test (Table 9). This result is consistent with the findings of Doğan and Özcan (2010) in their study. Like this result, pre-service teachers' views on the social and cultural impact of scientific knowledge improved significantly in favor of the post test (Table 10). These results show that explicit-reflective approach-based nature of science activities positively affect pre-service teachers' views on these dimensions of NOS. The general conclusion of this study is that although activities designed in aligment with the explicit-reflective approach hold significance in the NOS instruction, they alone do not sufficiently facilitate the comprehensive development of all aspects of NOS views to an acceptable level. However, consistent with the literature, explicit-reflective approach-based nature of science activities are generally effective in enhancing individuals' understanding of the NOS (Özer, Doğan, Yalaki, Irez & Çakmakçı, 2021; Pavez, Vergara, Santibañez & Cofré, 2016). For instance, a study concluded that explicit-reflective and history-based teaching had a positive impact on pre-service science teachers' understanding of the NOS (Göksu, Aslan, Özel & Şenel-Zor, 2016). Similarly, in another study, the integration of an explicit-reflective approach into chemistry lessons was observed to have a positive influence on students' understanding of the NOS (Erdoğan & Köseoğlu, 2015). Çetinkaya (2019) indicated that the explicit-reflective approach-based activities did not cause a change in the middle school students' views on the empirical, subjective, and creative aspects of NOS while it provided a significant shift in their views regarding the tentative dimension of NOS. In the study conducted by Özcan, Sarıtaş and Taşar (2020), it was observed that teaching based on explicit-reflective approach has a positive effect on developing views on the NOS. Consistent with the literature, our findings confirm that activities aligned with the explicit-reflective approach generally had a positive effect on the views of teacher candidates on the NOS. Because a meaningful statistical difference was observed in favor of post-test in the self-efficacy of teacher candidates for teaching the NOS. Nonetheless, the most detailed and sensitive finding of this study is that activities designed in accordance with the explicit-reflective approach are not effective in fostering the development of pre-service teachers' views in every question of the NOS. While pre-service teachers exhibited a general increase in their levels of acceptable views in all dimensions of NOS, their unacceptable view in one or more questions was maintained. For instance, the pre-service teachers' views in questions 1b, 2, and 6b did not developed to the desired level. While the percentage of unacceptable views in question 1b increased from pretest (44.4%) to posttest (50%), the percentage of acceptable views decreased from 36.3% to 26.6% from the pretest to the posttest. This finding shows that explicit-reflective approach-based nature of science activities did not enhance pre-service teachers' views on this dimension of NOS; instead, they led to negative views. The studies in the literature highlight that the understandings of teacher candidates between science, religion and philosophy are superficial (Turgut, Akçay & İrez, 2010). A similar result to question 1b was obtained in question 2 in which it was asked "What is an experiment?". With this question, an attempt was made to determine views about scientific research processes, but acceptable answers could not be elicited. This may be because many people think of "experiment" as an activity conducted only by a scientist in a laboratory. On the other hand, regarding the question numbered 6b which is about the changeability of scientific theories, the views of the pre-service teachers are not sufficiently developed. All these findings indicate that pre-service teachers continue to adopt the unacceptable view on these three questions about the NOS. In line with these findings, it can be inferred that pre-service teachers are very resistant to giving up their misconceptions about the NOS. However, we can interpret that the activities related to the aspects of the nature of science are either insufficient or not effective activities enough to change the views of teacher candidates, or it is plausible to infer that the number of activities related to these questions is insufficient. In support of this conclusion, the literature indicates that none of the approaches to teaching the NOS alone is adequate to develop all dimensions of the NOS at a desired level (Deng, Chen, Tsai & Chai, 2011; McDonald, 2010). From this perspective, in future studies, activities that are suitable for the explicit-reflective approach especially for these questions can be revised and used together with different teaching methods, so that their effectiveness can be investigated, or such activities can be used by integrating technology-assisted teaching. Since the technology supported learning environment tends to enhance students' motivation, the effectiveness of teaching may also increase. Another suggestion is to assess participants' misconceptions about the nature of science prior to instruction, and to revise and use activities suitable for an explicit-reflective approach in line with these misconceptions.

5. Conclusion

Overall, the results show that explicit-reflective approach-based nature of science activities can have an influence on the views about NOS and especially, participants' self-efficacy beliefs about teaching the NOS. This emphasizes the importance of incorporating such activities to statistically improve their beliefs concerning their ability to teach the nature of science and their views on NOS. However, the study has provided evidence that explicit-reflective approach-based nature of science activities are insufficient to promote the development of all the questions regarding the NOS views at an acceptable level. To foster a comprehensive understanding of all aspects of NOS, future research is crucial for investigating more focused interventions and for considering the integration of explicit-reflective approaches with other instructional methods. Considering these results, future studies could investigate the long-term impacts of explicit-reflective approach-based nature of science activities on teacher candidates NOS. Additionally, digital learning tools and resources can be incorporated into explicit-reflective NOS activities, which can contribute significantly to enhancing NOS understanding and self-efficacy.

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